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1937

LIMB PERSISTENCE FACTORS FOR YOUNG PONDEROSA PINE

1. Age of trees

The mean ages of stump height of trees on the north draw and south aspects were 58.6, 56.7, and 54.6 years, respectively. While the range was least on the north aspect, and the trees tended to be slightly older, the differences were not significant as indicated by the variance analysis given below.

Table I. Sources of variance in age at one foot stump of ponderosa pine on north draw and south aspects

Source of variation	Degrees of freedom	Sum of squares	Mean square	F	F/5%
Total	74	3636.8133			
Between aspects	2	205.4133	102.7067	2.13	3.13
Within aspects	72	3431.4000	48.2139		

Age of Trees

Source of variation	Degree of freedom	Σ□'s	M□	F	F tabular
Total	74	3636.8133			
Between aspects	2	205.4133	102.7067	2.130	3.13/5%
Within aspects	72	3431.4000	48.2139		

(1) $CT = \frac{(4242)^2}{75} = \frac{17994564}{75} = 239926.1867$

(2) Total Σ□'s = 75590 + 82003 + 85970 = 243563.0000
-239926.1867
3636.8133

(3) Aspect Σ□'s = 1857769
2002225
2143296
25) 6003290.00
240131.60000
239926.1867
205.4133

(4) Within Σ□'s = 243563.0000
240131.6000
3431.4

2. Diameter of trees

Source of variation	Degrees of freedom	$\Sigma\square$'s	$M_{\square}$	F
Total	74	1118.4975		
Between aspects	2	321.5651	160.7826	14.53
Within aspects	72	796.9324	11.0685	

(1) $CT = \frac{(1018.7)^2}{75} = \frac{1037749.69}{75} = 13836.6625$

(2) Total $\Sigma\square$'s = 14955.1600
13836.6625
1118.4975

(3) Aspect $\Sigma\square$'s = 71824.00
131044.00
151087.69

25) 353955.69 = 14158.2276
13836.6625
321.5651

(4) Within $\Sigma\square$'s = 14955.1600
14158.2276
796.9324

$2.828 \times \frac{3.48}{\sqrt{2s}} = 2.828 \times 0.7$

2. Diameter of trees

	Aspect			Difference significant if greater than
	North	Draw	South	
Mean diameter of sample trees	10.6	14.5	15.6	1.98 ($=2\sigma_d$)

The north slope trees are clearly growing at a slower rate than either the draw and south slope trees; the difference between draw and south slope not being significant. This difference in radial growth may be attributed primarily to density (i.e. competition). The average spacing of the sample trees is given in another analysis. It may be interesting to compare the mean diameter growth on the basis of ratios of DBH to age at breast high. The table below makes this comparison:

$\frac{10.6}{52.2} = 0.203$

$\frac{14.5}{51.3} = 0.283$

$\frac{15.6}{47.3} = 0.330$

While the average growth is little better on the south than the draw this should not be considered significant since the diameter differences were not significant

It is well to consider that draw sites as a rule are considerably more favorable than south slopes, but lack of competition on south slopes place a longer growing season favor.

Since the ages of the sample trees on the three aspects was not significantly different, it can be assumed that differences in mean diameter between these aspects is a reflection of rapidity of diameter growth. Analysis of variance indicates aspects to be a highly significant source of variation. The analysis is given in the table below.

Table II. Sources of variance in breast high diameter of second growth even-aged ponderosa pine.

Source of variation	Degrees of freedom	Σd's	M□	F-computed	F-tabular
Total	74	1118.4975			
Between aspects	2	321.5651	160.7826	14.53	4.92/1%
Within aspects	72	796.9324	11.0685		

The average spacing figure was obtained by averaging the distances to the boles of the nearest competing trees from the bole of the sample tree. This did not take into account the crown spread nor crown contact. Suppressed trees and reproduction was not considered as competing vegetation. The variance analysis indicates aspects as a highly significant source of variation.

Comparisons of aspect means is afforded in the table below.

Mean spacing sample trees	North	Draw	South	Difference significant if greater than
	10.0	17.2	27.2	5.6

It is seen that spacing was significantly different on all aspects. In fact the lowest spacing on the south was higher than the mean spacing on the north.

Average Spacing by Aspects

Source of variation	D.F.	$\Sigma\square$'s	M$\square$	F
Total	74	10,730.7467		
Between aspects	2	3,765.1467	1,882.5734	19.45
Within aspects	72	6,965.6000	96.7444	

(1) $CT = \frac{(1363)^2}{75} = \frac{1857769}{75} = 24770.2533$

(2) Total $\Sigma\square$'s = 35,501.000
24,770.2533
10,730.7467

(3) Between $\Sigma\square$'s = $(250)^2$ = 62,500
$(431)^2$ = 185,761
$(682)^2$ = 465,124
25 ⟌713,385 = 28535.4000
24770.2533
3765.1467

$\frac{9.85}{5} = 1.97$

The height to the lowest live limb gives an indication of the portion of the crown that is completely dead. This height is dependent on stand density, on tree height and inherent characteristics of the tree. Below are given the mean heights by aspect to the lowest live limb.

	Aspect			Difference significant if greater than
	North	Draw	South	
Mean height to lowest live limb	26.7	19.7	9.9	3.35
Mean height of trees	60.3	63.8	56.5	
Mean % of bole with dead limbs	44.3%	30.9	17.6%	5.6%

Even in the dense north slope stands the lower portion of the bole supporting dead limbs only is less than 50% although the actual live crown is not more than 1/2 the total length of the tree, the lower portion being ragged and often very asymmetrical.

Height to Lowest Live Limb

Source of variation	D.F.	Σ □'s	M□	F
Total	74	6,193.1467		
Between aspects	2	3,511.3867	1,755.6934	47.2
Within aspects	72	2,681.76	37.2467	

(1) $CT = \frac{(1408)^2}{75} = \frac{1982464}{75} = 26{,}432.8533$

(2) Total Σ□'s = 32,626.0000
26,432.8533
6,193.1467

(3) Aspect Σ□'s = $(666)^2 = 443556$
$(493)^2 = 243049$
$(249)^2 = 62001$
$25\overline{)748606} = 29944.2400$
-26432.8533
3511.3867

(4) Within Σ□'s = 32626.00
29944.24
2681.76

$\sqrt{37.24} = 6.10$

$2.828 \times \frac{6.10}{5} = 3.35$

The mean height of trees on the three aspects is given in the table below.

	Aspect		
	North	Draw	South
Mean height of trees - feet	60.3	63.8	56.5
Minus 1-ft. stump	59.3	62.8	55.5
Mean age @ stump	58.6	56.7	54.6
Mean height growth per year	1.01	1.11	1.02

It is seen that mean height growth of dominant trees is not significantly poorer on the south slope. Lack of competition and longer growing season on the south slope account for the good showing. Where the soil is essentially as deep as on the north slopes and the elevational zone is not much different it is a moot question whether stand density can account for any acceleration in height growth of dominant and codominant trees.

A comparison of mean diameters is afforded in the table below.

No. of whorls in the section of butt log

Source of variation	Degrees of freedom	$\Sigma\square$'s	M$\square$	F	
Total	149	833.0933			
Between aspects	2	64.4933	32.2467	9.28	4.75/1%
Between sections	1	245.7600	245.7600	70.6	6.81/1%
A x S	2	22.8400	11.4200	3.29	3.06/5%
Within aspects (error)	144	500.000	3.470		

(1) $\frac{\left[\sum_{1}^{150} (W)\right]^2}{150} = \frac{(1306)^2}{150} = \frac{1,705,636}{150} = 11,370.9067$

(2) Total $\Sigma\square$'s = 12204.0000
11370.9067

833.0933

(3) Between aspects = $(457)^2$ = 208849
$(389)^2$ = 151321
$(460)^2$ = 211600

50) 571770 = 11,435.4000
11,370.9067

64.4933

(4) Between sections $\Sigma\square$'s = $(749)^2$ = 561001
$(557)^2$ = 310249

75) 871250 = 11616.6667
11370.9067

245.7600

(5) Interaction: $(258)^2$ = 66564
$(199)^2$ = 39601
$(216)^2$ = 46656
$(173)^2$ = 29929
$(275)^2$ = 75625
$(185)^2$ = 34225

25) 292600 = 11,704.00
11,370.9067

333.0933
-310.2533

22.8400

(6) Error = 12204
11704

500.00

Nat. Pruning Study

Analysis of Variance - Total Height of Trees

Source of variation	Degrees of freedom	Σ□'s	M□	F	
Total	74	9455.3867			
Between aspects	2	648.6667	324.3338	2.66	N.S.
Within aspects	72	8806.72	122.3156		

(1) $CT = \frac{(4514)^2}{75} = \frac{20376196}{75} = 271682.6133$

(2) Total Σ□'s = 281138.0000
271682.6133
9455.3867

(3) Aspect Σ□'s = 2537649
2274064
1996569

$25\overline{)6808282} = 272331.28$

272331.28
271682.6133
648.6667

(4) Within aspect Σ□'s = 281138.000
272331.28
8806.72